Measuring Density: Working Definitions for Residential Density and Building Intensity

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Overview

Density is a controversial term. Increased density is feared by those who imagine ugly buildings, overshadowed open space, parking problems, and irresponsible residents. It is promoted by those who value urbane streetscapes, efficient infrastructure supply, walkable neighborhoods, and increased housing options.

However, within these debates is a surprising lack of clarity about what counts when considering density, and about how to measure it. This design brief outlines a number of general considerations in measuring density and then proposes twenty measures that quantify different aspects of place such as residential population and dwelling density, and the intensity of building on a site. Some of the measures are easy to use in practice, and some more difficult. All focus on residential areas. While some can be applied to other kinds of uses of land the translation is not always direct. Indicators of density in mixed use environments are particularly lacking.

Key Points

• Density is a number of units--people, dwellings, trees, square feet of building--in a given land area.

• Density varies greatly depending on the base land area used in the density calculation. The parcel or site density is almost always higher than the neighborhood density, because at a neighborhood scale much land is included in the base land area calculation that does not have houses.

• Population density depends on both dwelling unit density and household size. Given a certain dwelling unit density, the population density will be lower with small households such as empty nesters than with large families with several children.

• Intensity of building development is measured with several physical indicators related to how much built area there is on the site. Most measure building bulk and are quite crude. More important issues of design quality are much more difficult to quantify.

For more detail, supporting facts, and references read on.....

Terminology

Density is a much used term. At its simplest, **density is a number of units in a given area**. However, there are no agreed-upon standard definitions of density, rather each location and profession has come up with an idiosyncratic view.

A key area of difference and confusion is in the **base land area calculation**—what is included and what is excluded to make density figures truly comparable. Is it only the site or the entire neighborhood? This is the key dimension of variation in the range of density definitions in Part A of the working definitions section of this paper. Practically it results in a huge variation in density as can be seen below in the table. These densities are for a hypothetical site set in an area where each residential area has the same site density in dwelling units (DUs) per acre but different density definitions lead to very different measures. (The different kinds of density are explained in the next section.)

Table: Comparison of Density Measures for the Same Location	
Site density	10 DUs per acre
Block density	8 DUs per acre
Net residential density	10 DUs per acre
Net neighborhood density	6 DUs per acre
Gross neighborhood density	5 DUs per acre
City density	4 DUs per acre
Metropolitan density	3 DUs per acre

The difference between these numbers is that as the base land area being considered increases there are more and more nonresidential uses added into the calculation. These nonresidential uses such as offices and open space have residential densities of zero and thus lower average

residential densities across these wider areas. These more inclusive densities are important measures and have much to say about such issues as the overall walkability of the site. Given these figures, however, if an overall aim is to achieve a city density of 4 dwelling units per acre then the site density will need to be much greater.

Similarly, **household size affects population density**. An area with a site density of 10 DUs per acre may have a site population density of 15 people per acre in an area full of empty nesters and seniors, or a site population density of 35 people per acre in an area with many households with children or extended families. This makes a great deal of difference in terms of how many people are present to support community facilities. However, it is much harder for governments to regulate household size as opposed to dwelling numbers so most policy discussions focus on densities of dwelling units.

One area of confusion is between density and other related terms. On one side are **physical measures of the intensity of use of land** including measures of building bulk and coverage. A number of such measures are listed in Part B of the working definitions section. These measures say something about how big the buildings are, although they are only rough measures.

Large setbacks are not always attractive. Large areas devoted to the automobile can also force the neighborhood and city level densities down, even when the residential areas have many dwellings on a small amount of land. Photo: DCAUL

Photo: Ann Forsyth

Beacon Bill in Boston is an area where high lot coverage and small setbacks combine to make a high quality environment.

Many of the most charming environments in the world have buildings with small setbacks, high building coverage, and relatively small distances between buildings. More open space is not necessarily better, particularly when such open space is poorly designed.

Another area of confusion is the issue of **crowding**, which is a perception that there are too many people (Churchman 1999). However, in housing studies crowding is generally operationalized as the number of people per room, per bedroom, or square foot. Obviously density and crowding are not the same and are not even related. It is possible to live at very high density in a spacious apartment with no crowding, and conversely it is possible to live in a detached farm house that is crowded in terms of having many people per room.

In addition there is **unclear terminology even when it appears to be specific**. Net density refers to densities where the base land area calculation focuses only on the parcel or, if covering a larger

areas, excludes certain uses. Gross densities do not have such exclusions. However, as is obvious from the set of working definitions **there are a number of "net" and "gross" density definitions** and so what area is being considered needs to be specified. Saying net or gross is not enough.

While people often talk about low, medium, and high densities **there are no agreed upon standards for what constitutes high, medium, and low densities**. A high density in Minneapolis might be medium or even low density in Paris or Singapore.

Often people **confuse density with building type** and assume, for example, that detached houses are lower density than attached housing types. While this is generally true it is not always the case. A high-rise tower with large units set on a park-like site may be lower density than a set of detached houses on small lots.

A larger question is that of **perceived density** (Rapoport 1975). Perceived density is not highly related to actual density but is profoundly affected by landscaping, aesthetics, noise, and building type. Often, when people say an area is dense, they base this assessment on a perception that a development is ugly, has little vegetation, and has caused parking problems for neighbors, rather than a count of the actual number of units per acre. Design can make an enormous difference to perceived density.

Finally, some people associate higher densities with **social and economic characteristics** such as renter and low-income households, and high crime neighborhoods. They may misperceive densities because of this, underestimating the densities of more affluent areas with larger numbers of owners. The definitions in this paper will help add clarity to such discussions.

Working Definitions

A range of potential density definitions is outlined below, based on a review of the work in the reference list, general knowledge of density calculations used in urban design regulations, and unique measures developed for Design Center projects. (See the http://www.designcenter.umn.edu for examples.)

The ones most used by the Design Center are marked with an * . Those developed by the Design Center are indicated although it is likely that these definitions have been created earlier by others and we welcome correspondence indicating those uses. We will cite them in subsequent editions of this paper.

Many of these density measures are simple to calculate but some are quite difficult and need a large team of workers.

Part A. Dwelling unit (DU)/residential population (RP) densities

Parcel or block densities (all "net" densities)

1. Parcel Density (PD): DUs or RP divided by total site/parcel area (all uses). This is often used by developers. It is easy to calculate with GIS but also fairly simple by hand if there is only one parcel. However, since parcel boundaries are not always visible on the ground this form of density can be hard to calculate from physical observations.

2. Block Density (BD): DUs or RP divided by block area measured to the curb. This is relatively easy to measure from aerial photos and census data, and reflects a unit that is part of the experience of place, the block (Design Center). However, if the block is not surrounded by roads, for example where it abuts open space, the boundaries can be less clear.

3. Part Block Density (parcel approximation) (PBD): DUs or RP divided by a clear subset of the block area measured to the curb. Sometimes the parcel boundaries are not highly visible and so a part-block density is a useful approximation for a

parcel density. However, it does include the sidewalk area and so will deliver a slightly lower density number than a site/parcel density (Design Center).

Neighborhood

4. Net Neighborhood Residential Dwelling/Population Density (NNRDD/NNRPD): DU or RP divided by total land area devoted to residential facilities.

This is a calculation that involves defining both a neighborhood and residential land within that neighborhood. Unless there is a truly compelling reason to choose another unit, the *neighborhood* should be a census tract or a city-delineated neighborhood and should be clearly defined; typically these will be in the 100-500 acre ranges.

Care must be taken in assigning land to *residential uses* rather than, say, recreation--the key is to find equivalent elements in different residential designs. In lower density areas the base land calculation typically includes dwelling lots/yards, driveways, private gardens, and ancillary structures e.g. garages. In higher density designs the equivalent base area includes private access drives, resident parking, play spaces, gardens, and landscaped areas adjacent to and related to the residential use. Excluded are the following areas if not directly beneath a dwelling: commercial and industrial areas, shops, commercial garages, public parks/playgrounds, undeveloped vacant land, vacant unsuitable land, schools, churches, public streets, public parking spaces. This calculation is relatively simple using GIS but difficult otherwise. This definition is adapted from Alexander (1993) who has an even more detailed list of exclusions.

5. Net Neighborhood Residential Building Type Density (NNRBTD). Density calculation very similar to definition number 4 but counts only the dwellings of one type in a neighborhood e.g. townhouses and the land area associated with that type. This is a relatively simple calculation using GIS, if the appropriate data exist, and like other

densities in this list can be calculated for dwelling units or residential population (Design Center).

6. Net Neighborhood Density (NND): DU or RP divided by the neighborhood area with the base land area calculated to exclude city-wide uses in the neighborhood. Neighborhoods should be defined as in #4. Included in the neighborhood land area are residential land, streets, and neighborhood type uses—schools, parks, churches/synagogues/ temples etc. and neighborhood shopping. Excluded are city-wide businesses, public uses, high schools and colleges, major arterials, major regional parks, and vacant and unusable land. These exclusions can be difficult to calculate (adapted from Alexander 1993). This is different to the Net Residential Densities in that it includes other neighborhood uses while still excluding uses seen as regional.

*7. Gross Neighborhood Density (GND)/Gross Census Tract Density (GCTD): DU or RP divided by the total neighborhood area. The total neighborhood area should be defined as in density definition number 4 but in this case there are no exclusions. This is easy to calculate although it may be skewed by regional uses such as regional parks. The Gross Census Tract Density is particularly useful as it is available across the United States from Census information and does not rely on local data.

City and larger

8. City Density (CD): DU or RP divided by the entire developed area of the city or town. In built out local government areas this is in practical terms the entire city. On the urban edge, it includes only developed land, a more complex calculation (adapted from Alexander 1993). This is a gross density.

9. Metropolitan Density (MD): DU or RP for US Census Metropolitan Statistical Area divided by total land area. This calculation includes undeveloped areas which will lower the overall figures, but is nationally comparable. The US Census prepares

such density figures. This is also a gross density.

10. Net Residential Density at City or Metropolitan Level: DU or RP divided by residential land at a City or larger level. This kind of calculation is possible using large Geographical information System databases. The presence of housing in mixed use areas makes it complicated in areas with a large percentage of such areas.

Part B. Built area intensity measures at parcel or block level

11. Floor Area Ratio (FAR)—Built floor area on all floors divided by the parcel area. This calculation is often based on actual usable floor area rather than footprint area that includes wall thickness. However, this varies from municipality to municipality.

12. Building Site Coverage—Area of ground floor footprint of building divided by the parcel area. This measure indicates the amount of open space left on the site.

*13. Building Block Coverage—Area of ground floor footprints of buildings divided by the block area measured to the curb. This is a calculation that can
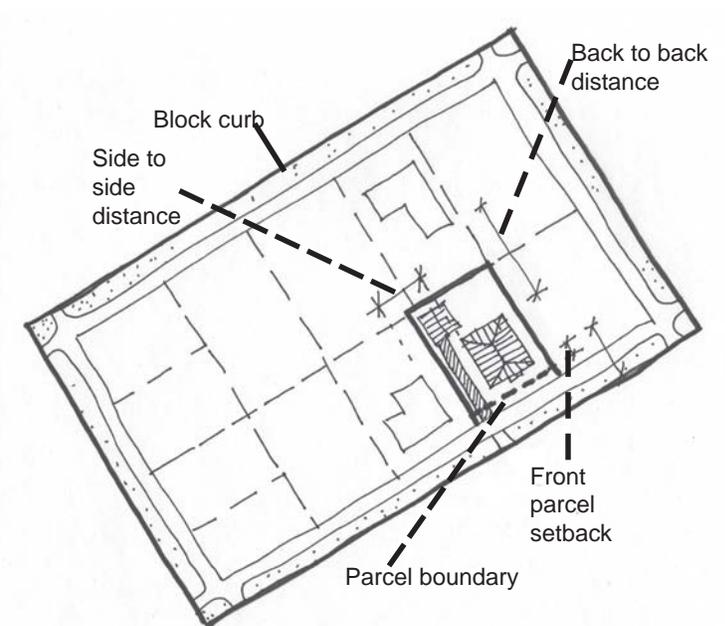
Density and building intensity factors on a simplified block.

be done when the parcel boundaries are not known. It also reflects the actual experience of an environment better than parcel by parcel calculations.

14. Impervious Surface Parcel Coverage—Area of ground floor building footprint plus paved parking lots, drives, sidewalks, paths, decks and other build-ings divided by site or parcel area. This measure indicates the area of land that has been built upon or paved but does not easily take account of porous paving systems or decks designed for water infiltration.

15. Impervious Surface Block Coverage--Calculation as for number 14 but using the block as the base land area.

16. *Building Height in feet for parcel.*

17. *Front Parcel Setback in feet for parcel. This is the distance from the front facade of the building to the front property line.* It is a measure of building intensity. It is a typical measure in zoning regula-tions.

18. *Front Curb Setback in feet, with the setback of each building from the curb averaged by building over a block.* This is a rough measure of the experience of the setback as it includes the sidewalk and planting strip area (boulevards in Twin Cities terminology).

19. *Side to side distance between buildings, measured in feet and averaged across a block.* This is another rough measure of building bulk.

20. *Back to back distance between buildings, measured in feet and averaged across a block.*

Other measures

There are a number of other potential measures of density, and even more of perceived density. For example, the proportion of detached or single family homes in relation to other housing types will affect the perception of density, even though this proportion is calculated on a base of housing units and not land areas. Similarly, measures of crowding are typically based on

people per room. This paper is meant to provide a starting place for examining measures of density and building intensity from their physical base and to clearly distinguish these from separate but related measures of housing mix, crowding, or social and economic characteristics.

Density and Intensity Measure Summary

* Relatively difficult to calculate due to exclusions
** Easily calculated from field observations and measurements from aerial photos supplemented with web-accessible census data
*** Easily calculated using GIS parcel level database, including assessors data and/or census data and TIGER line files

1. Parcel Density ***
2. Block Density**
3. Part Block Density (parcel approximation)**
4. Net Neighborhood Residential Dwelling/ Population Density ***
5. Net Neighborhood Residential Building Type Density***
6. Net Neighborhood Density*
7. Gross Neighborhood Density**
8. City Density***
9. Metropolitan Density (MD)***
10. Residential Density at City or Metropoli-tan Scale***
11. Floor Area Ratio***
12. Building Site Coverage***
13. Building Block Coverage**
14. Impervious Surface Parcel Coverage***
15. Impervious Surface Block Coverage**
16. Building Height**
17. Front Parcel Setback***
18. Front Curb Setback**
19. Side to side distance***
20. Back to back distance***

Fine Print Facts

Some of the most talked about density definitions of the 1990s were the density thresholds for designation as priority funding areas (PFAs) under the State of Maryland's smart growth regulations. Under these regulations, the state would place infrastructure only in areas that reached certain densities. Specifically, they had to be planned for 2.0 units per net residential acre (excluding public recreation, habitat, wetlands, and public open space) in existing areas with sewer or water. For greenfield or peripheral sites, this is raised to 3.5 units per net acre excluding those same public uses (Maryland Office of Planning 1997).

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